MICROWAVE INTEGRATED RETRIEVAL SYSTEM (MIRS): Hydrological Products and Applications

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Help from: G. Chirokova, P. Meyers, H. Meng

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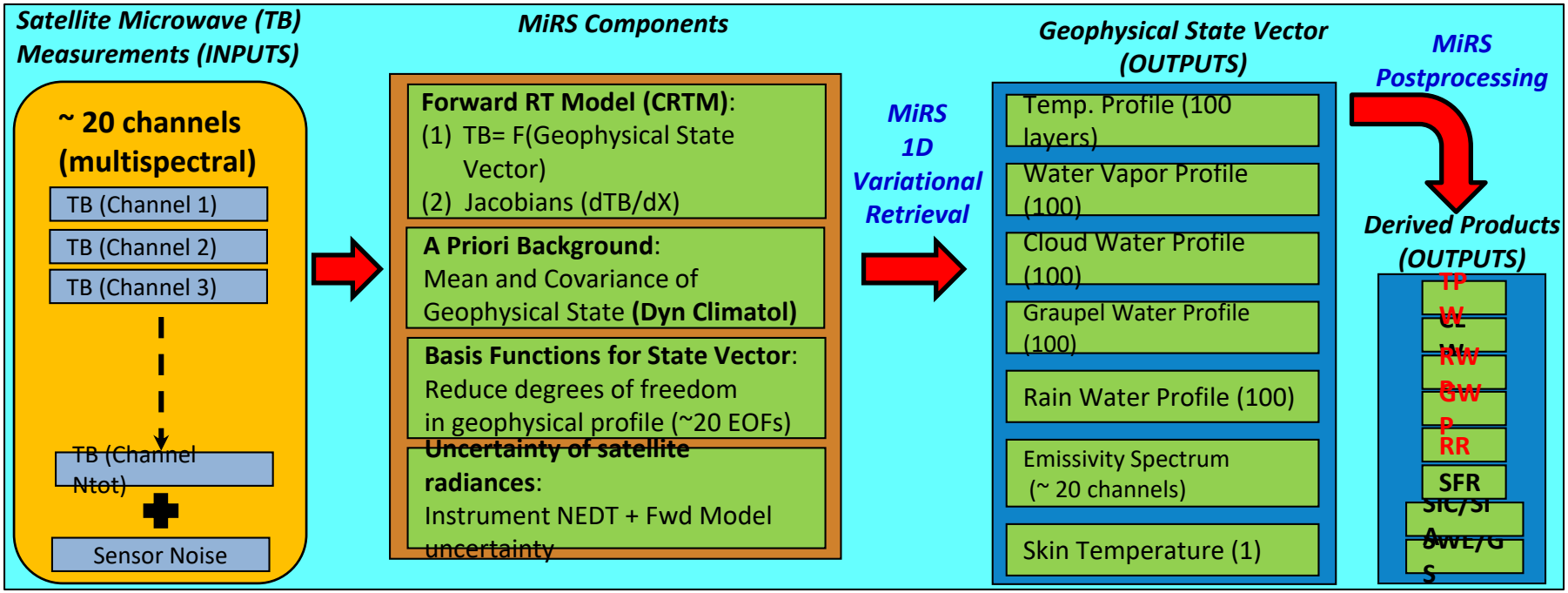
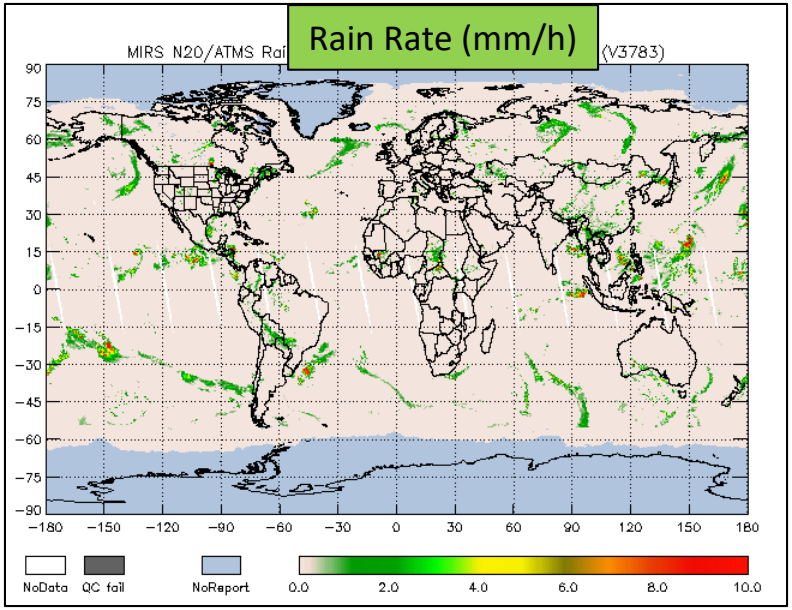
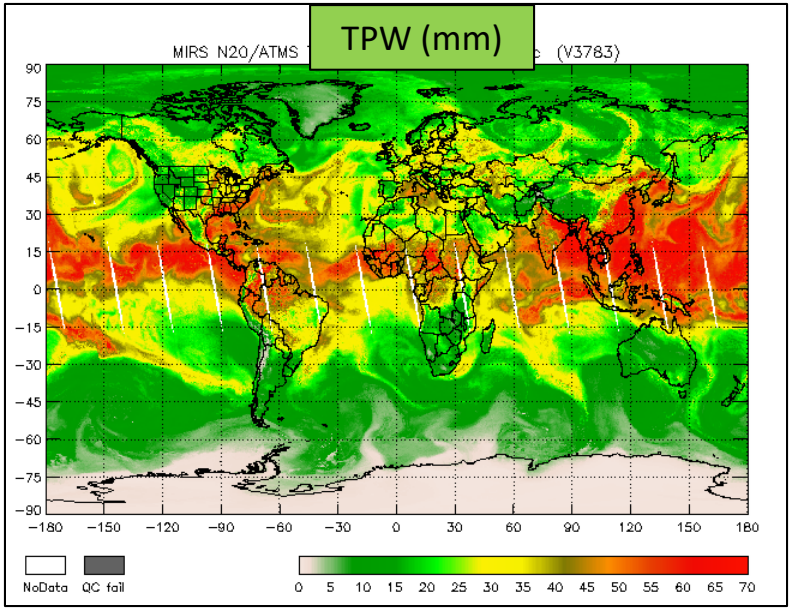
Algorithm Overview

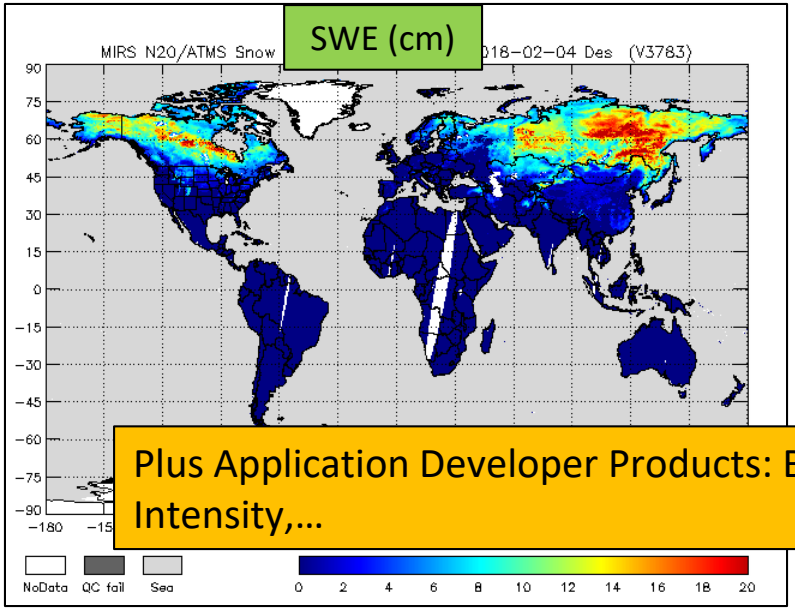


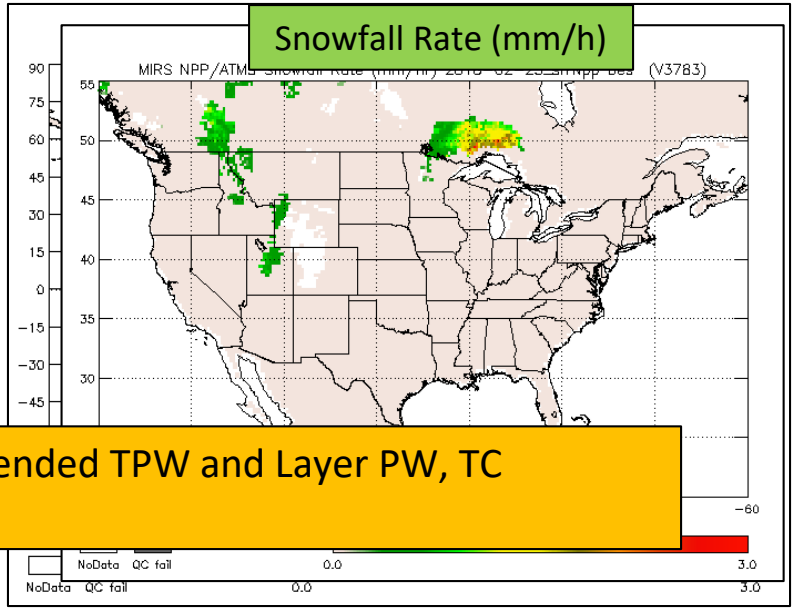
- MW Only, Variational Approach: Find the "most likely" atm/sfc state that: (1) best matches the satellite measurements, and (2) is still close to an a priori estimate of the atm/sfc conditions.
- **"Enterprise" Algorithm: Same core software runs on all satellites/sensors; facilitates science improvements and extension to new sensors.**
- Initial capability delivered in 2007. Running v11.2 since Jan 2017 on SNPP/ATMS, N18, N19, MetopA, MetopB, F17, F18, GPM/GMI, Megha-Tropiques/SAPHIR. (eventually MetopC…)
- Delivery of v11.3 (extended to NOAA-20/ATMS) to operations on **8 June**.
- External Users/Applications: TC Analysis/Forecasting at NHC, Blended Total/Layer PW Animations at NHC and WPC (CSU/CIRA, U. Wisconsin/CIMSS), **CSPP Direct Broadcast (U. Wisconsin)**, NFLUX model (NRL, Stennis), Global blended precipitation analysis at NOAA/CPC (CMORPH),…
- **All N20 results here are generated with MiRS v11.3 (offline processing in STAR), and TDR data generated in IDPS (Block 2 processing).**

Examples of MiRS Products with Hydrology Applications









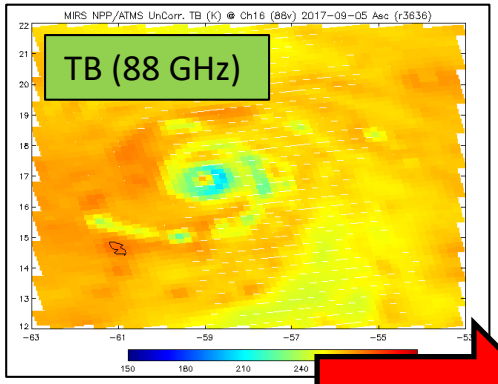
Plus Application Developer Products: Blended TPW and Layer PW, TC Intensity,…

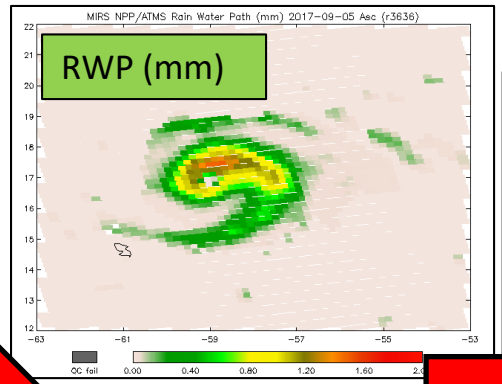
MiRS RR Algorithm

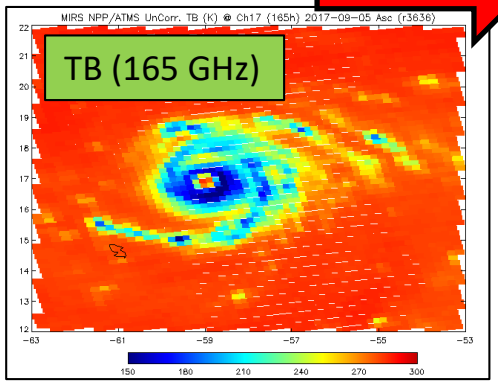
- 1DVAR retrieves pRWP and pGWP on 100 p layers
- Postprocessing:
  - Vertically integrate to obtain CLW, RWP GWP
  - Apply equation previously trained on mesoscale model simulations:

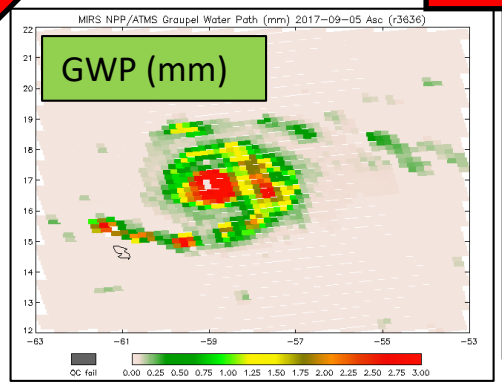
$$\square_{\square,\square,\square} = \square_{\square} + 3.879 \times \square + \square^{1.103}$$

$$\square_{\square} = 2.339 \times \square^{1.156}$$

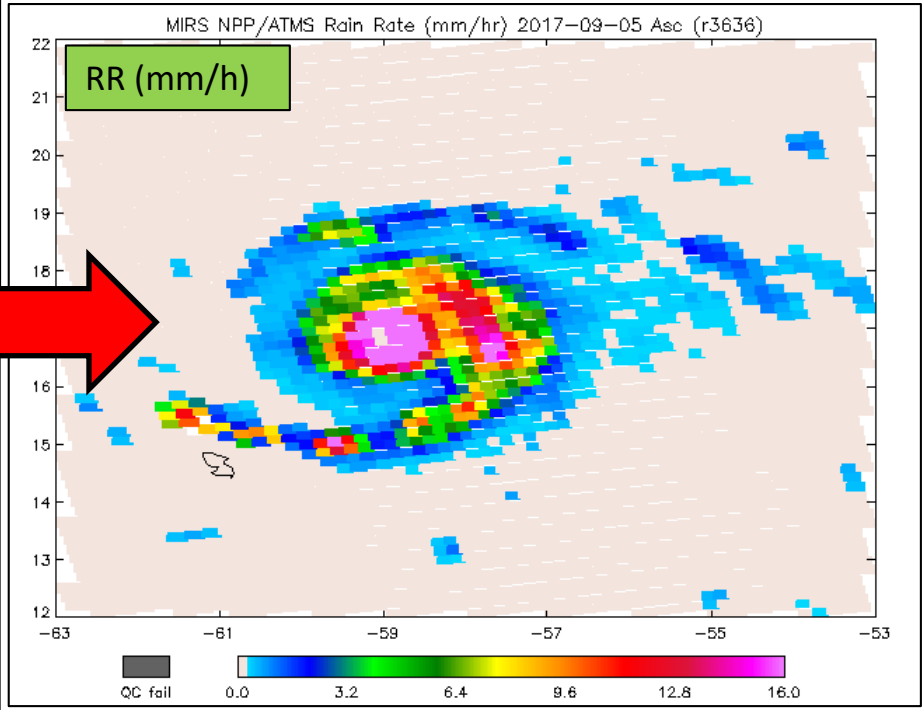






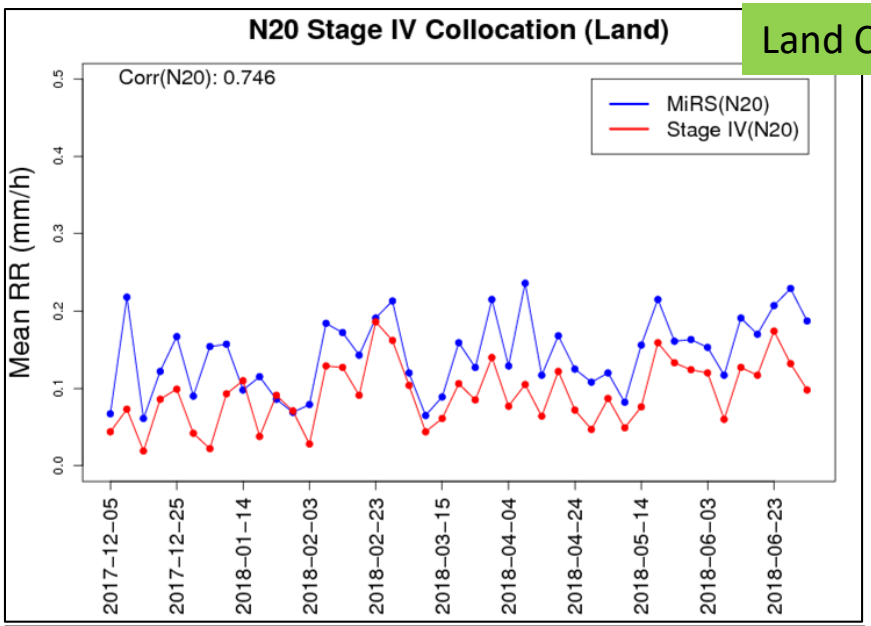


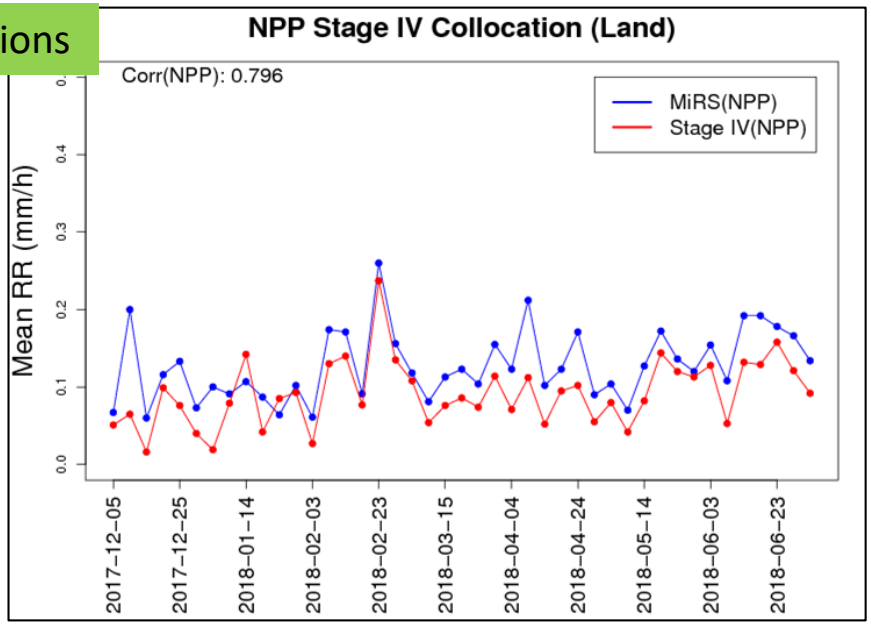
Hurricane Irma

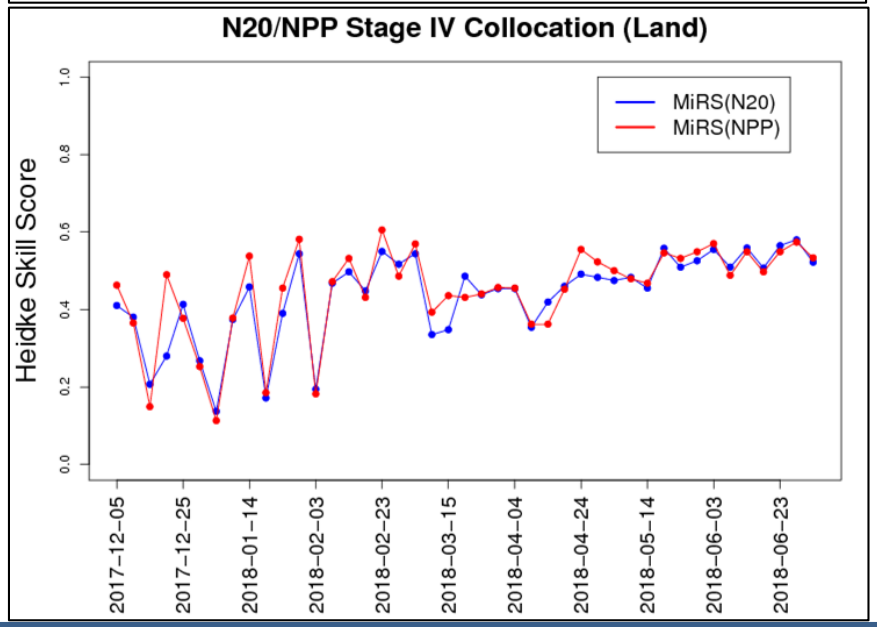


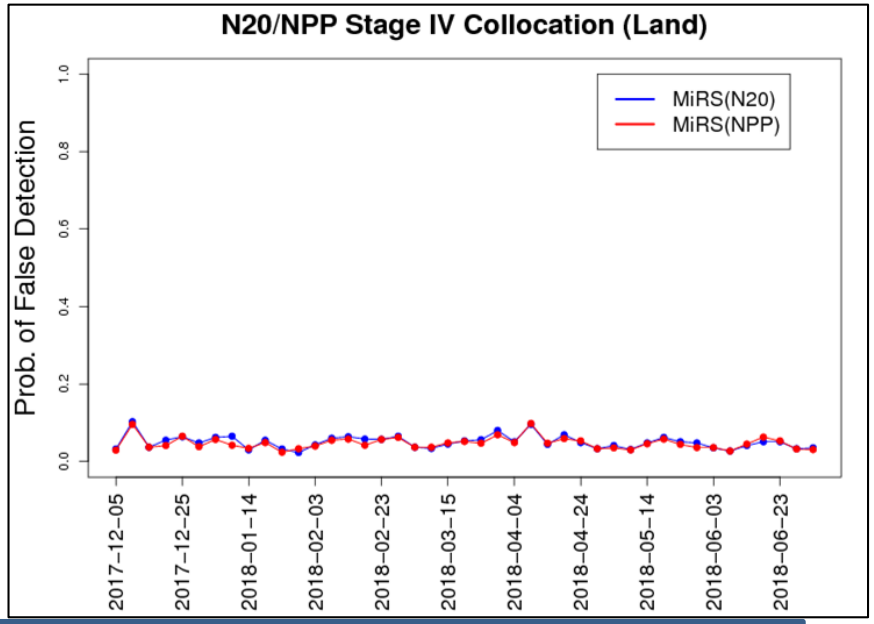
RR validation: N20 and SNPP vs. Stage IV 5-Day CONUS Averages (Dec 2017 – Jul 2018)

Land Collocations



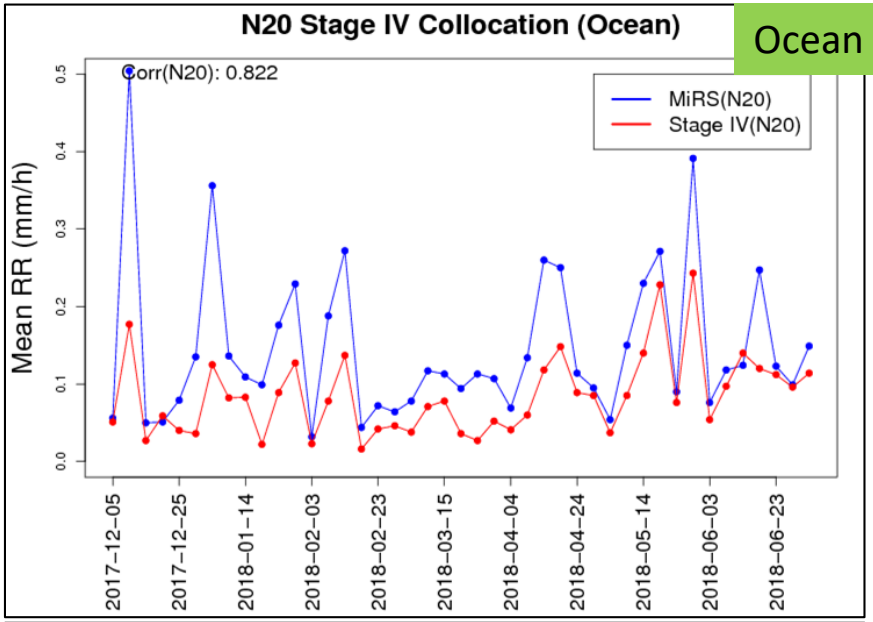


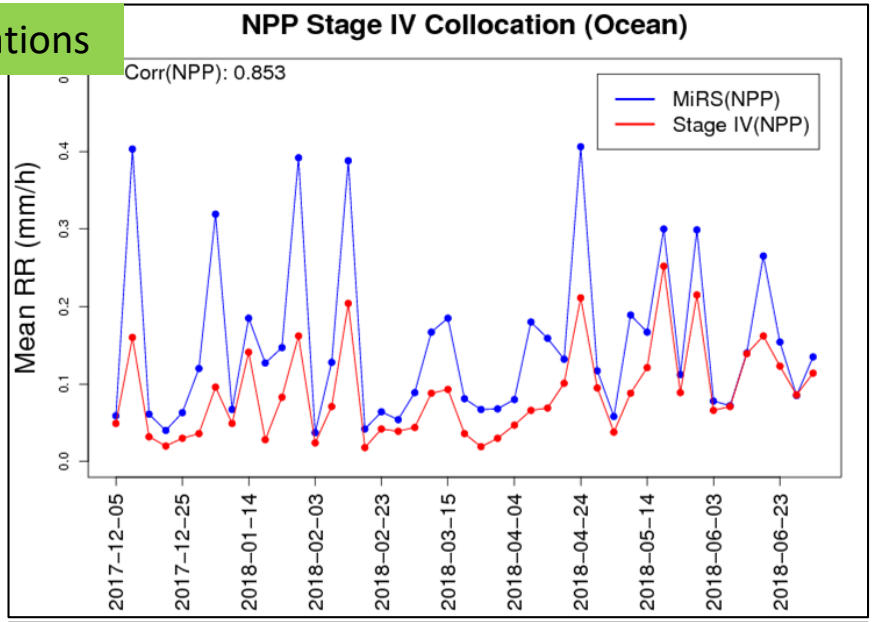


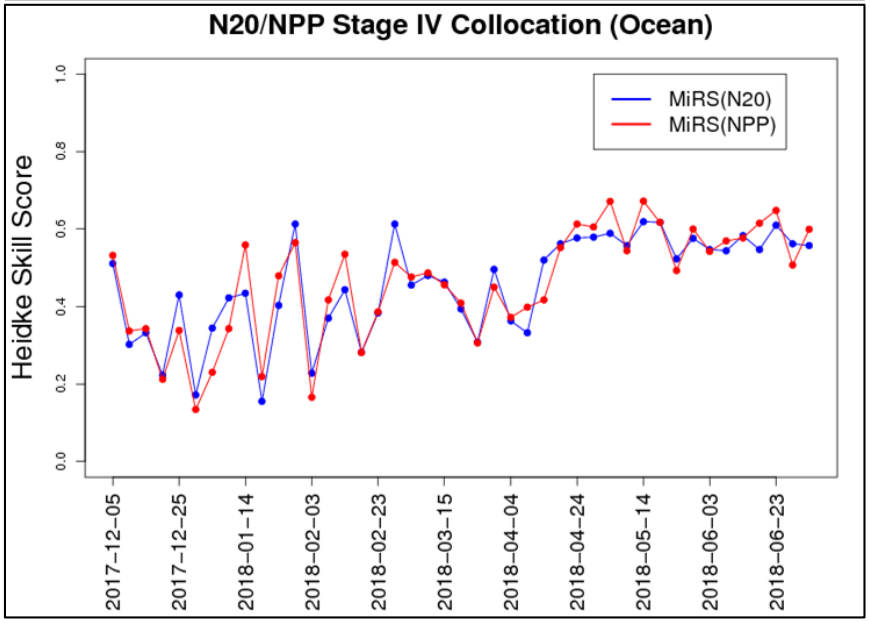


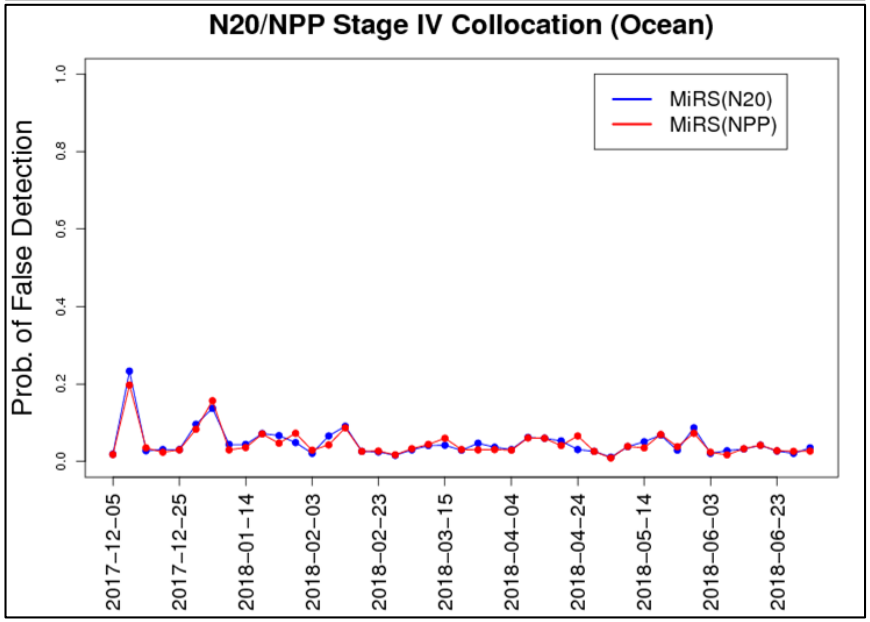
RR validation: N20 and SNPP vs. Stage IV 5-Day CONUS Averages (Dec 2017 – Jul 2018)

Ocean Collocations





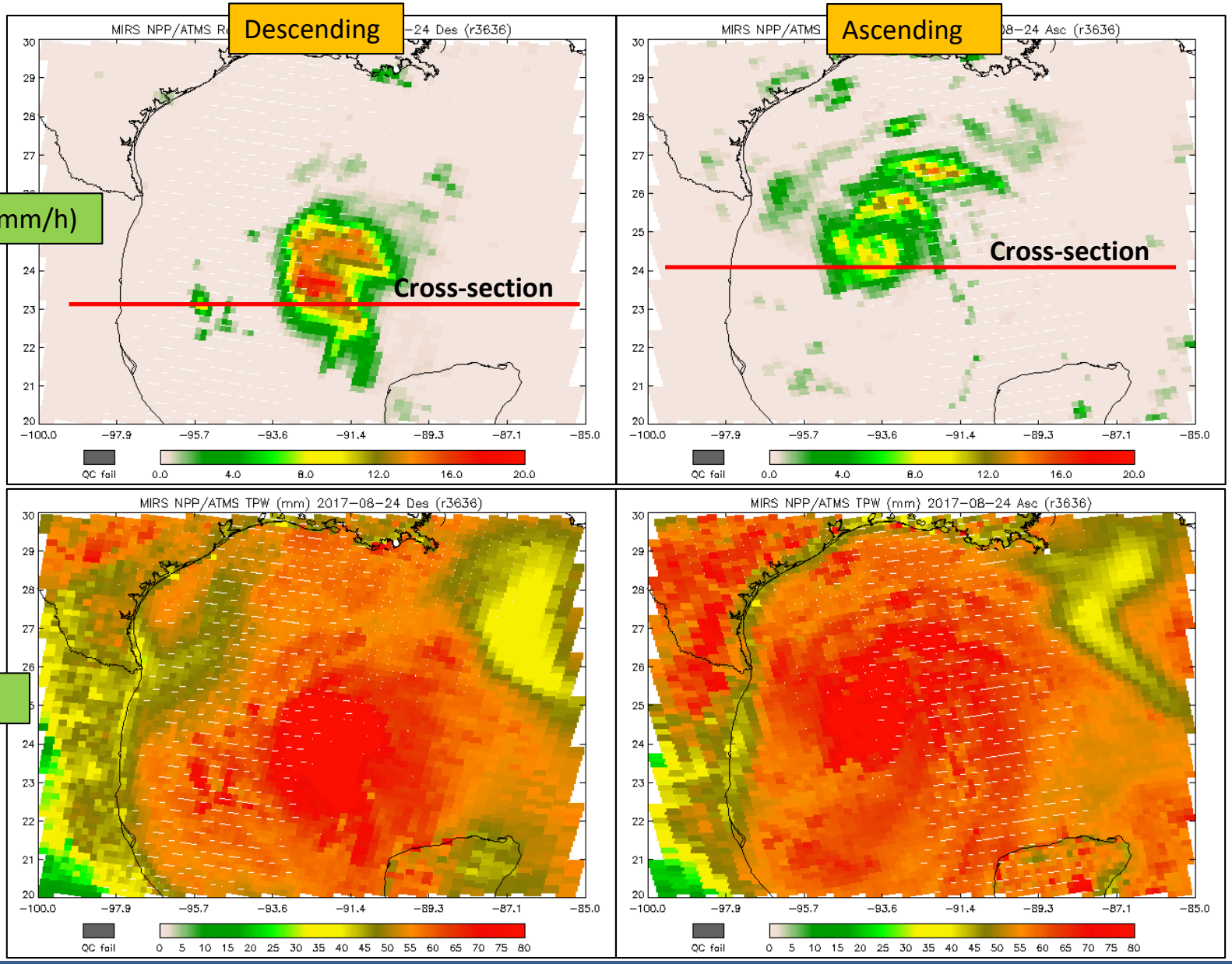




Hurricane Harvey: MiRS ATMS Rain Rate and TPW, 24 August 2017

Rain Rate (mm/h)

TPW (mm)

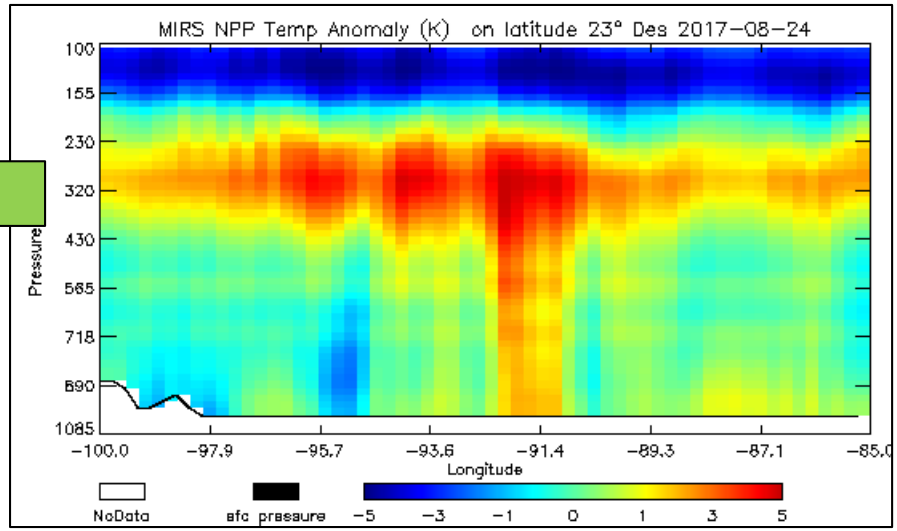


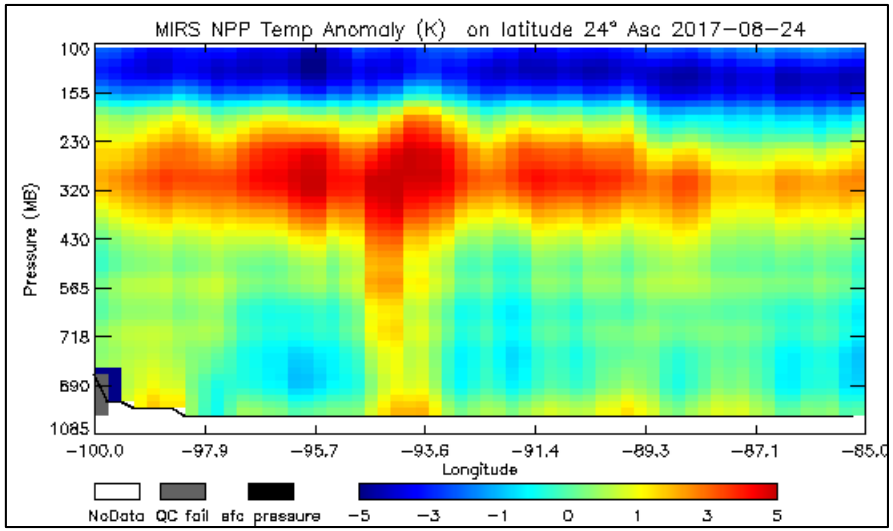
Hurricane Harvey: MiRS ATMS and ECMWF Temperature Anomaly Cross-sections, 24 August 2017

Descending

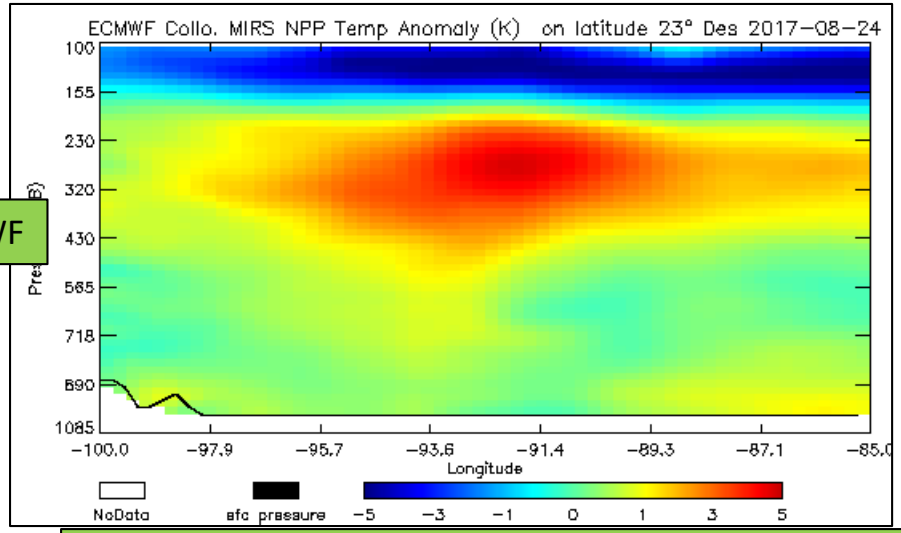
Ascending

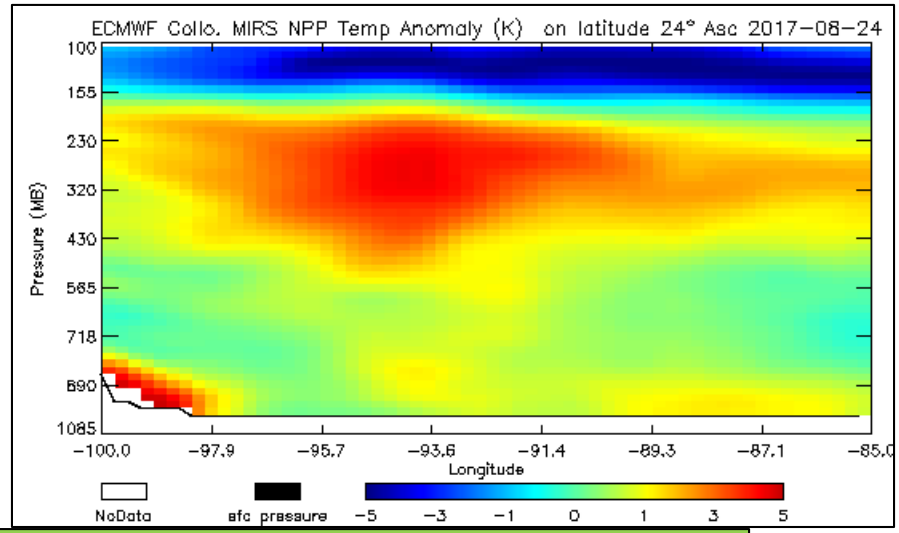
MiRS





ECMWF



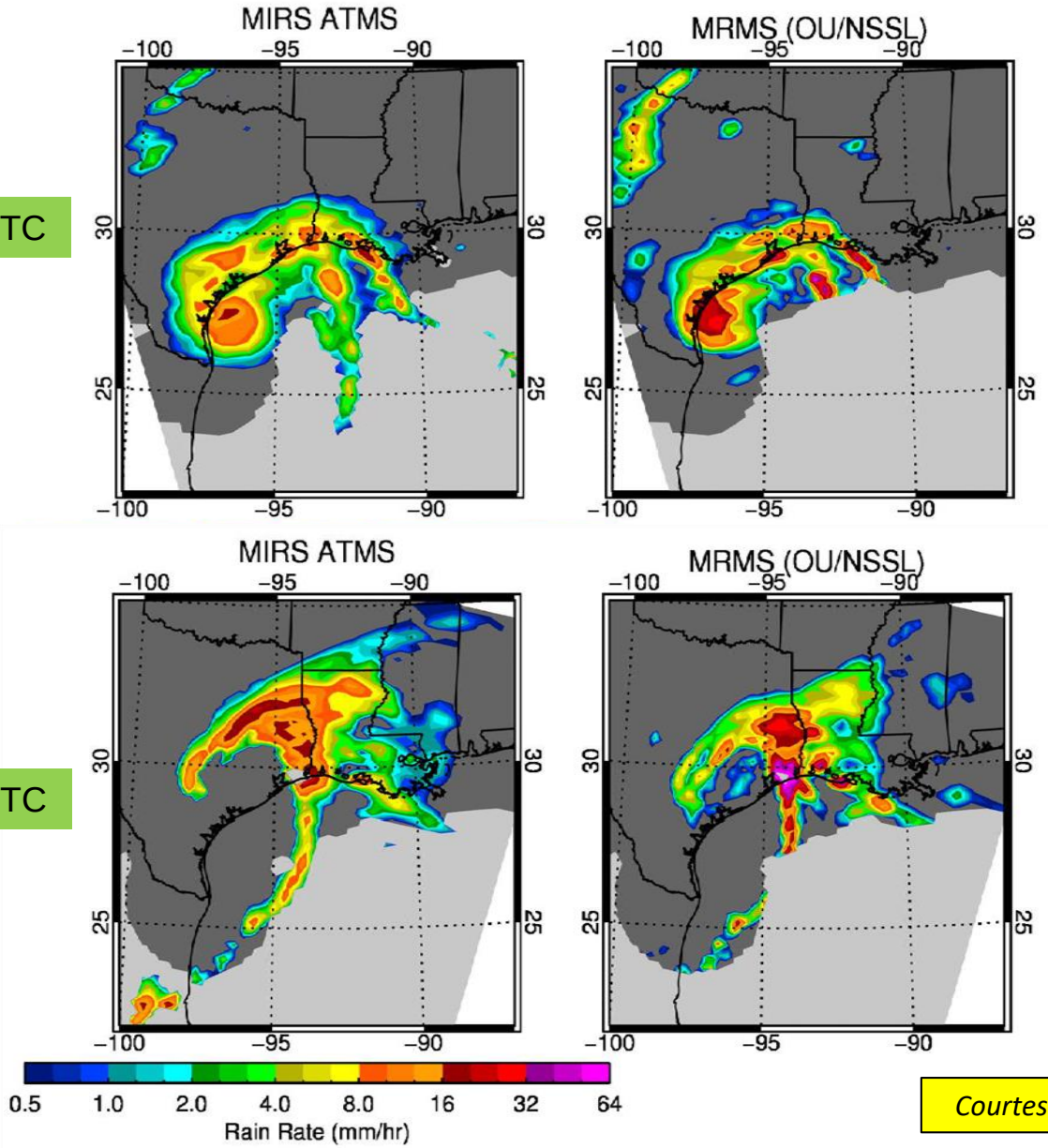


- Upper level T anomaly good agreement with ECMWF
- Lower level anomaly is artifact of rain contamination (see last year's presentation)

Hurricane Harvey: Comparison with MRMS

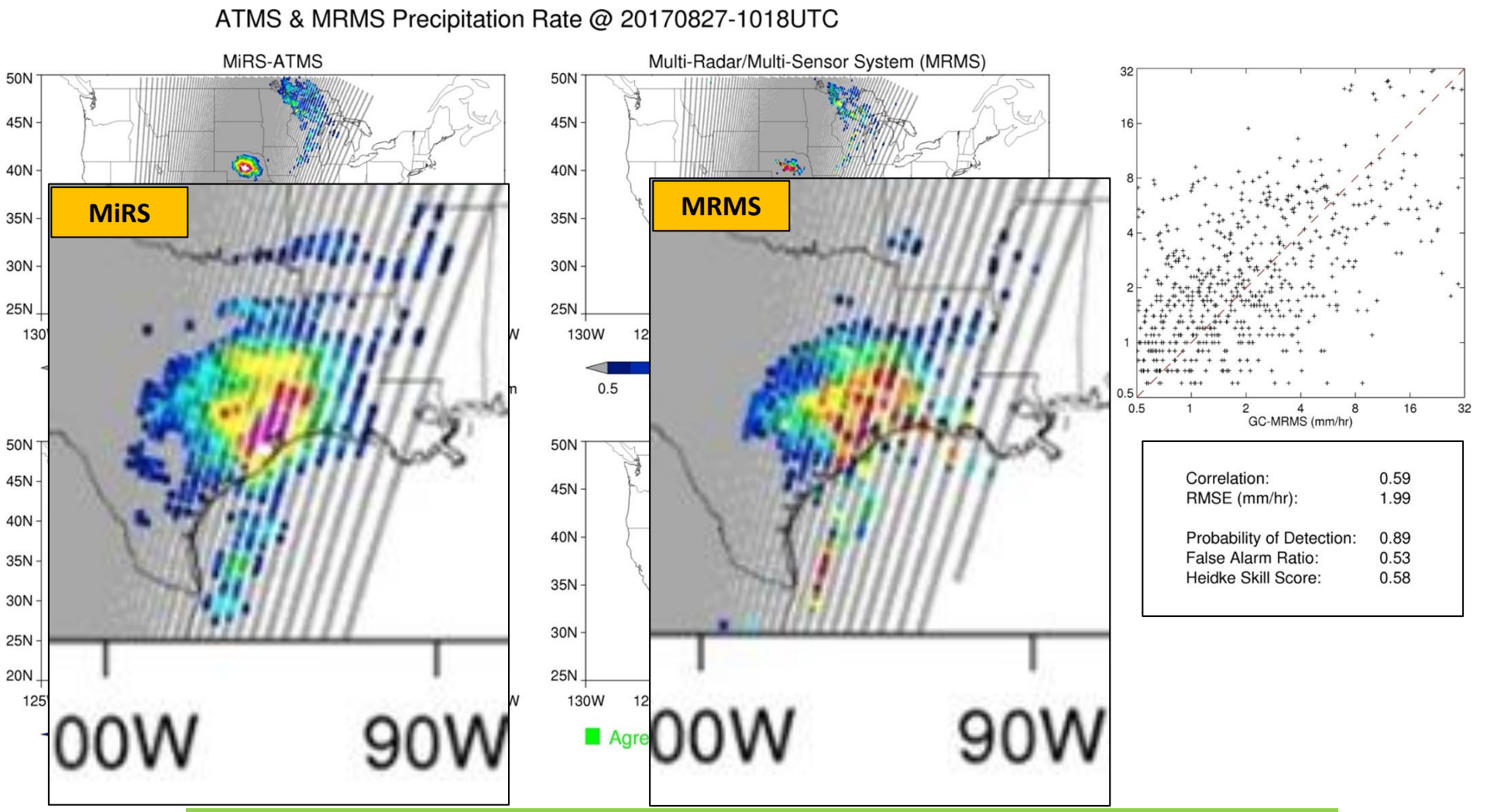
2017-08-25 1852 UTC

2017-08-28 0820 UTC



Courtesy of Pat Meyers (CICS-MD)

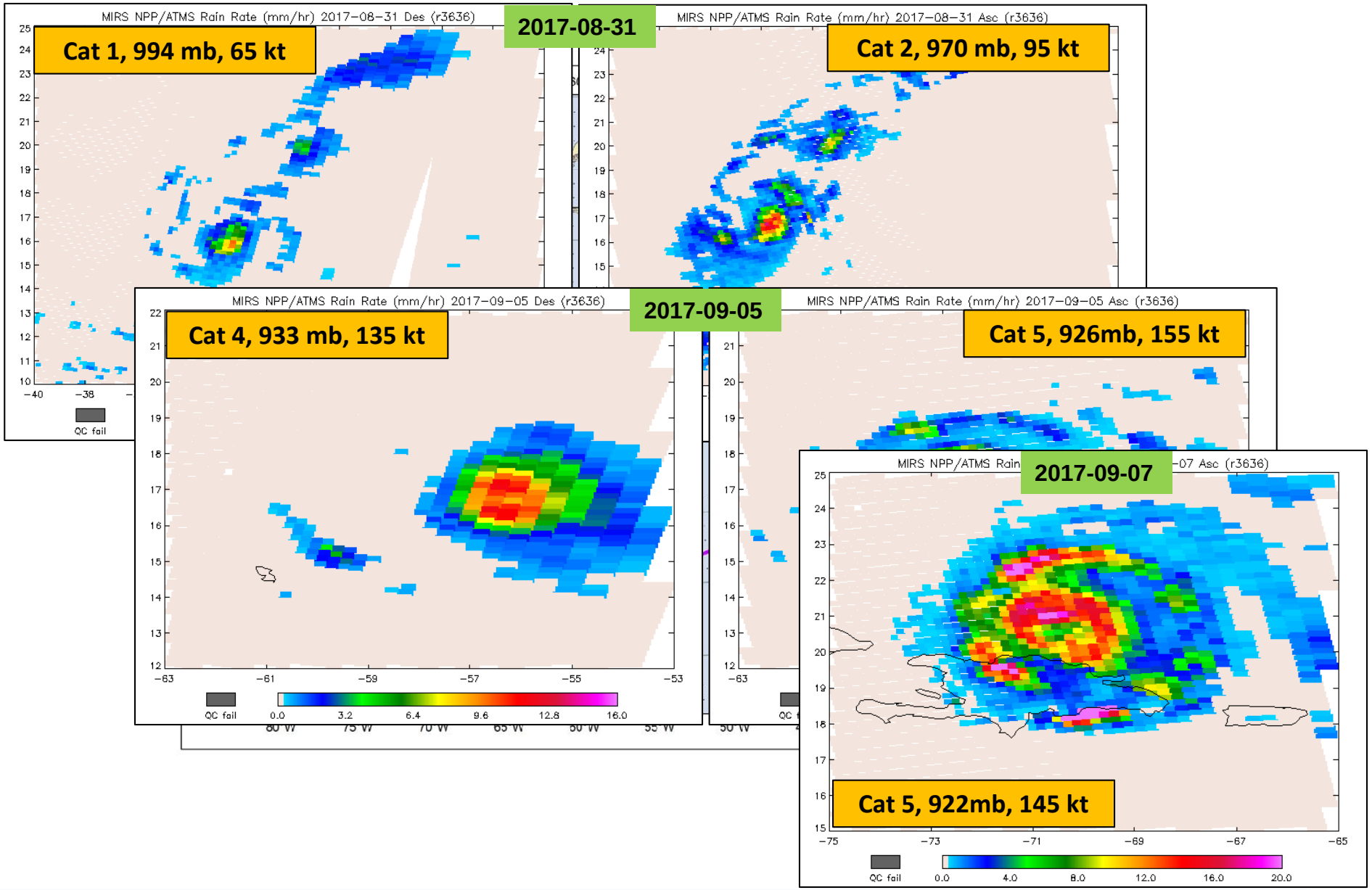
Hurricane Harvey:
27 August, Day of Extreme Flooding



- MRMS: Operational Blended Radar-Gauge Analysis, 1 km resolution
- Both satellite and MRMS detected rainfall rates > 25 mm/h

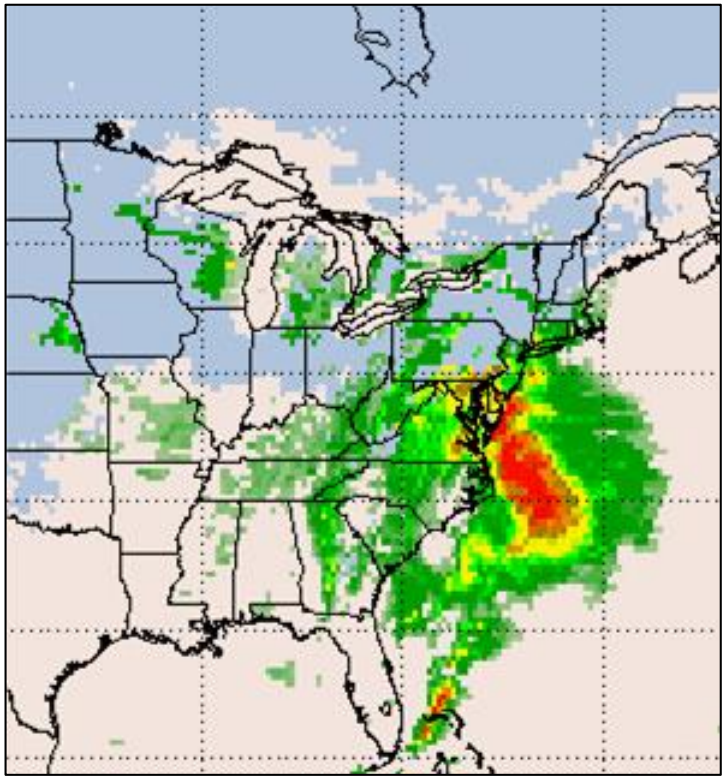
Courtesy of Pat Meyers (CICS-MD)

Hurricane Irma: Westward progression and Intensification



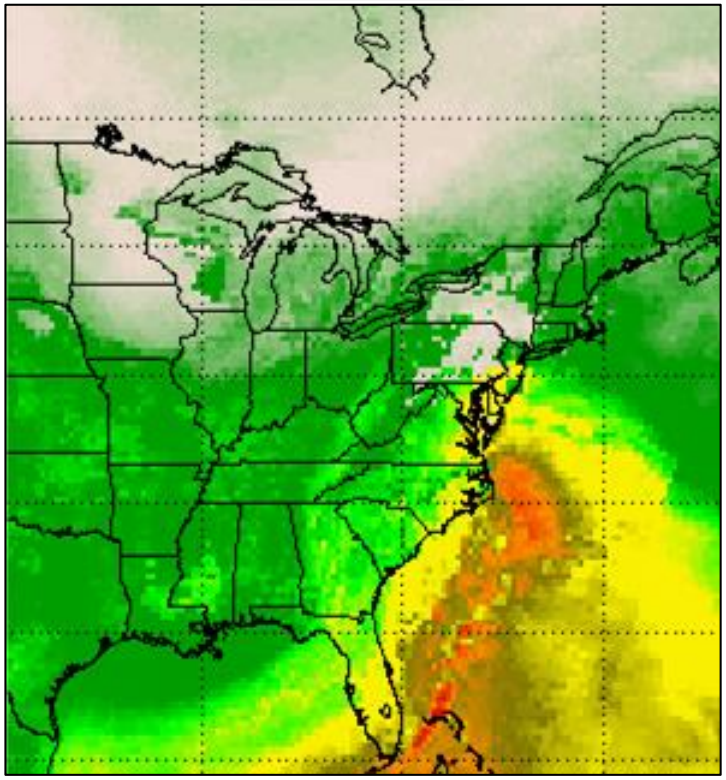
Northeastern Snowstorm: 14 March 2017

Rain rate (mm/h)



NoReport 0.0 2.0 4.0 6.0 8.0 10.0

TPW (mm)



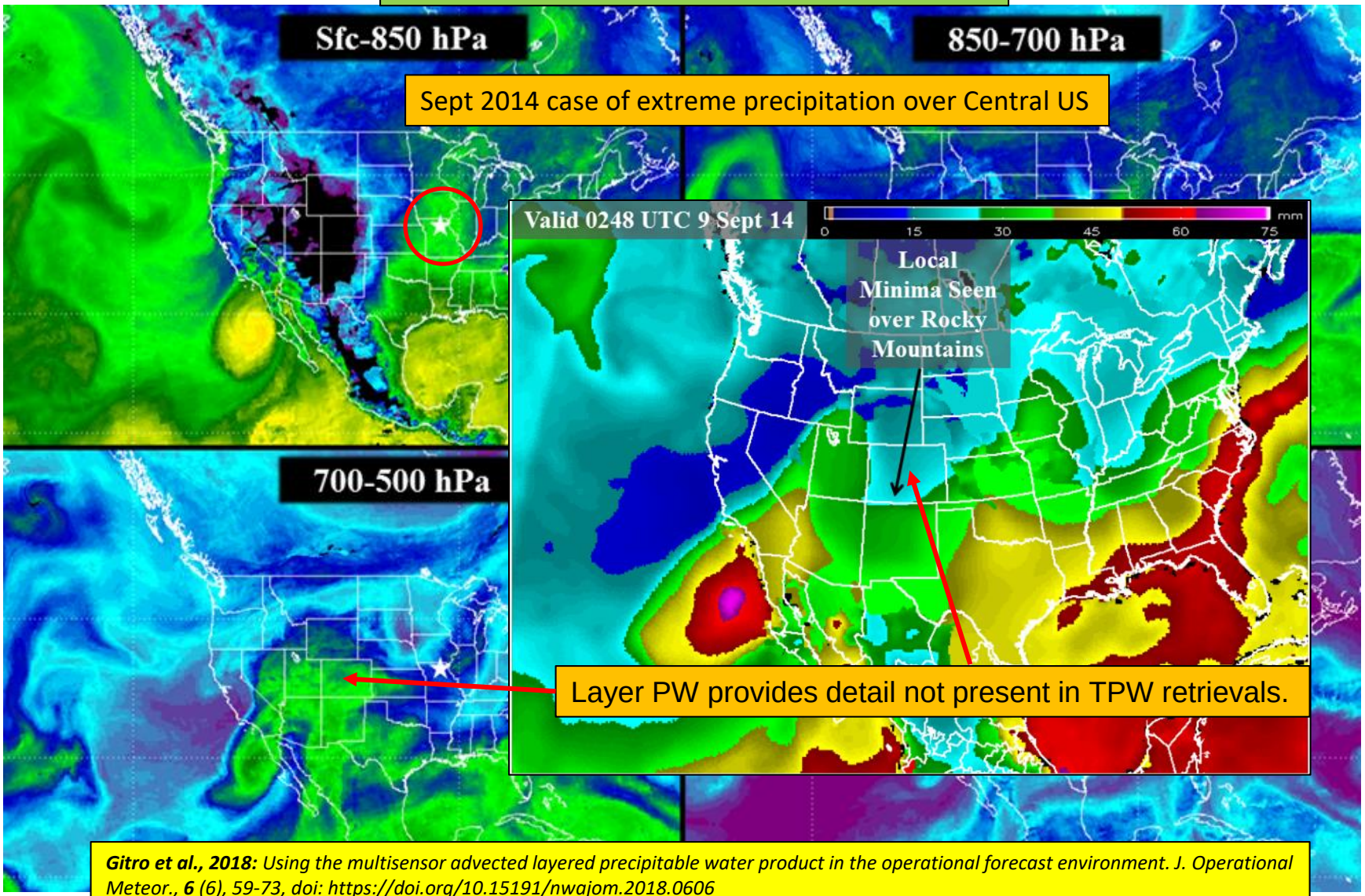
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70

- High rain rates over ocean and southern areas (Caribbean moisture plume)
- Missing RR over snow covered land (algorithm does not retrieve precipitation when snow cover detected)
- Complementarity with SFR algorithm (retrieves over land only); see Huan Meng's presentation next.

Application: Blended Layer Precipitable Water
Combines MiRS WV from up to 7 Polar Satellites for Rapid Refresh and Advection (NWP-based winds)

To be implemented at NHC and WPC

Courtesy of John Forsythe



Gitro et al., 2018: *Using the multisensor advected layered precipitable water product in the operational forecast environment. J. Operational Meteor.,* ***6*** *(6), 59-73, doi: https://doi.org/10.15191/nwajom.2018.0606*

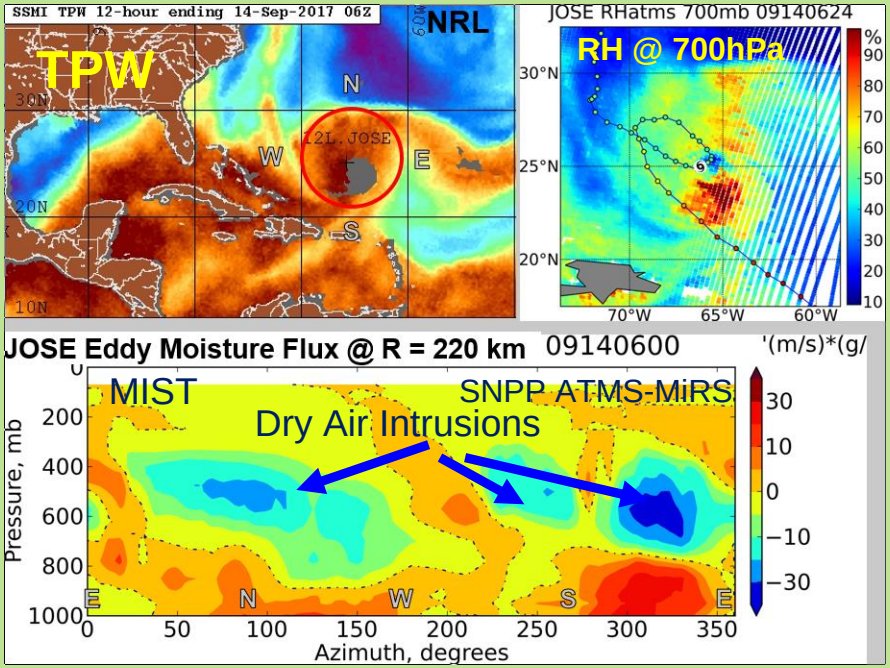
Application Using MiRS Data: Moisture In-Flux Storm Tool (MIST) (under development)

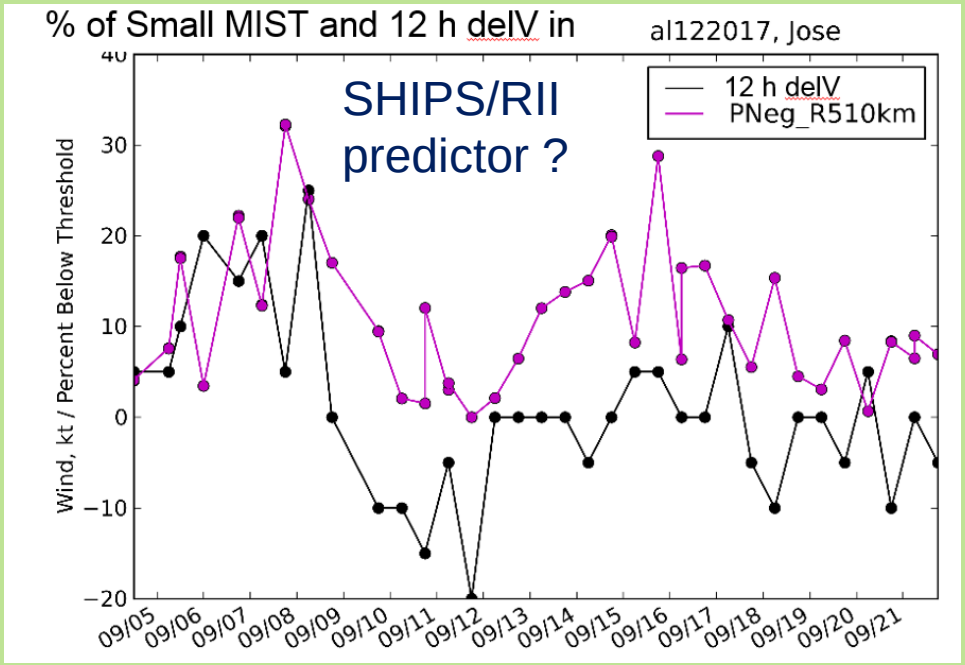
Dry-air intrusions:

- adversely affect TCs: inhibit convection, enhance cold downdrafts, contribute to storm asymmetry
- detected with TPW, LPW, WV imagery which do not provide quantitative information and do not always reflect moisture changes at mid-levels

MIST:

- detects and quantifies dry-air intrusions
- potential predictor for statistical TC intensity forecast models (SHIPS, LGEM, RII)

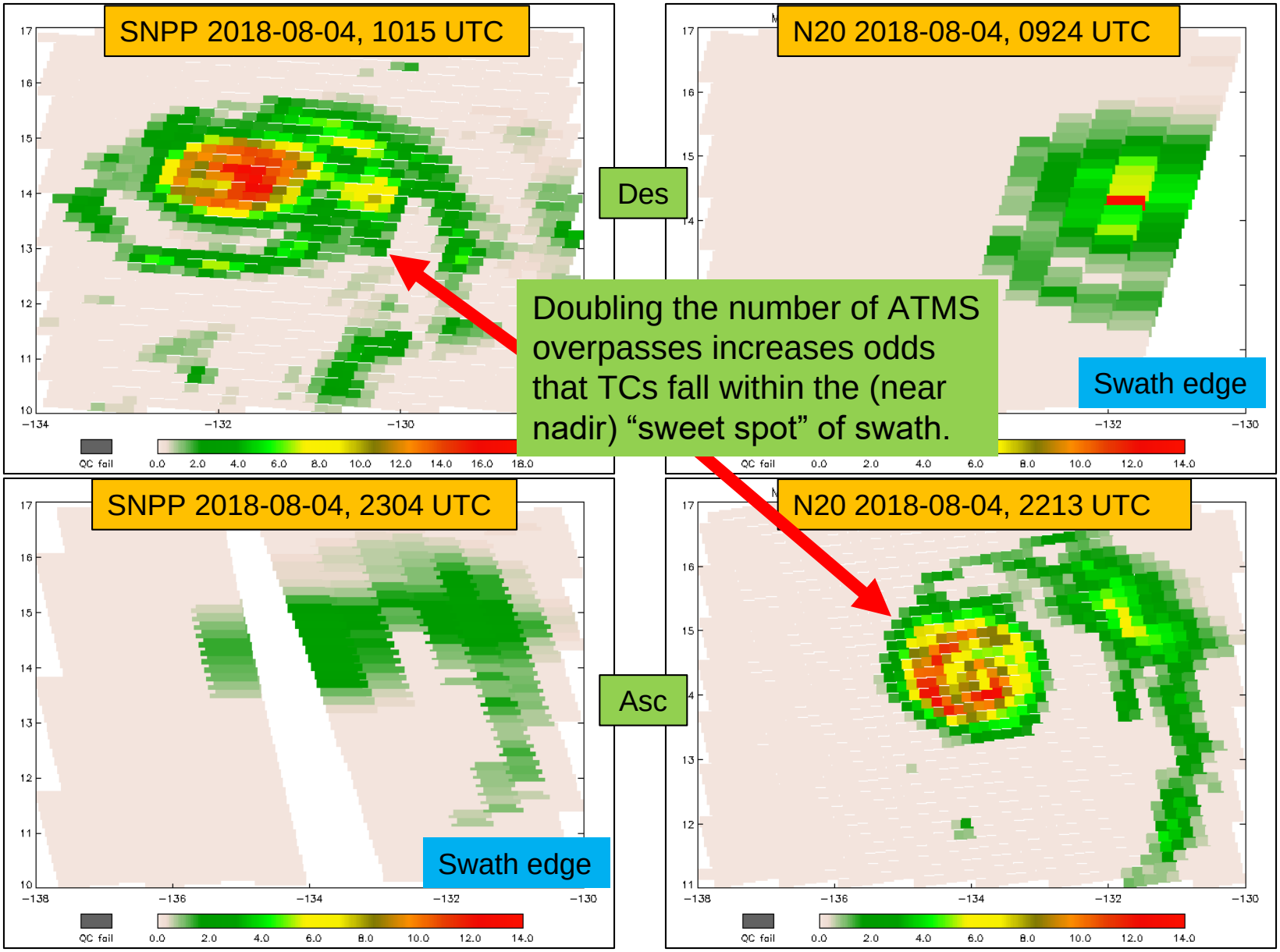




MIST shows moisture flux at R = 220 km from the storm center as a function of azimuth

Galina Chirokova (CIRA), Mark DeMaria (NOAA/NWS/NHC), John Knaff (NOAA/NESDIS)

Two Operational ATMS Better Than One: MiRS Rain Rate for Hurricane Hector



Summary

- MiRS products with hydrology applications: RR, RWP, GWP, CLW, TPW, Snowfall Rate, Sea Ice Concentration, Snow Water Equivalent
- Some products are used in downstream applications, e.g. Blended Layer and Total PW, TC Intensity
- Continued N20 validation (RR, TPW, SIC, SWE) indicates **extremely good agreement** with SNPP, and performance against external references very similar to SNPP
- Validation maturity status: Provisional maturity
- MiRS v11.3: Extension to N20 ATMS processing, delivered to OSPO/NDE on 8 June; operations possibly in September
- Path Forward
  - Continued validation, e.g. rain rate, CLW, cryosphere, T, WV,…
  - Additional DAP delivery in late 2018 (updated radiometric bias corrections, possible science improvements)
  - Stakeholders/user needs; continue collaboration with applications developers and users…
- MiRS data available at CLASS, and STAR ftp (S-NPP/ATMS, GPM/GMI, NOAA-20/ATMS)
- Software package available for download **https://www.star.nesdis.noaa.gov/mirs**

Extra Slides

Outline

- Algorithm Overview
- Rain rate validation
  - N20 and SNPP ATMS comparisons with Stage IV
- Case Studies
  - Hurricane Harvey (August 2017)
  - Hurricanes Irma and Jose (Sept 2017)
  - Northeastern Snowstorm (14 March 2017)
  - Advantage of 2 operational ATMS for TC monitoring
- Summary and Path Forward

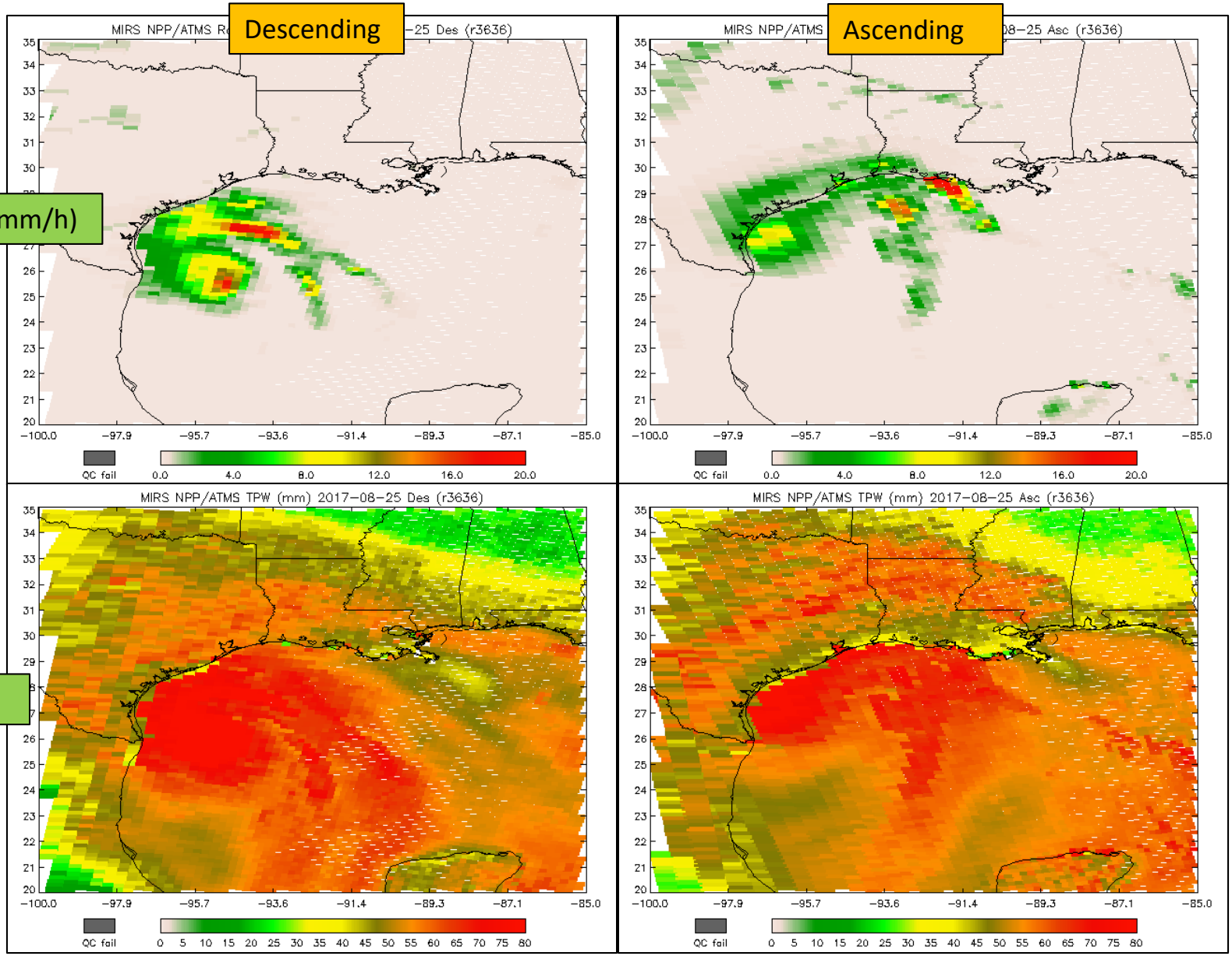
Hurricane Harvey: MiRS ATMS Rain Rate and TPW, 25 August 2017

Descending

Ascending

Rain Rate (mm/h)

TPW (mm)



MiRS ATMS Rain Rate and TPW: 27 August 2017

Descending

Ascending

Rain Rate (mm/h)

TPW (mm)